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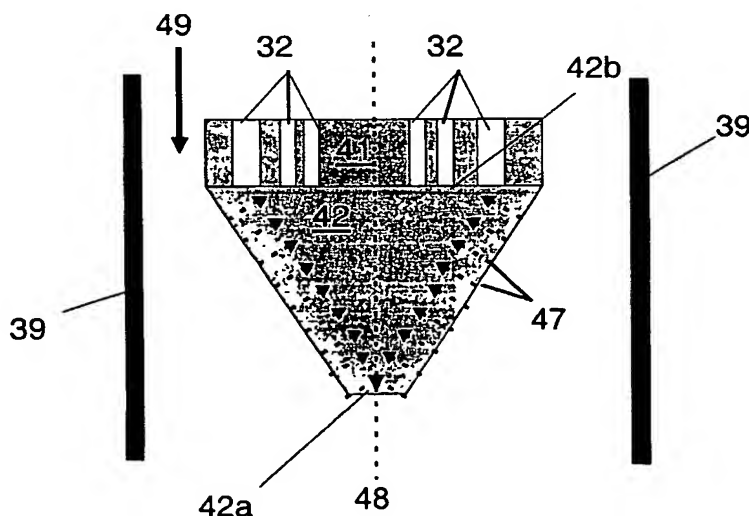
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- (71) Applicant (for all designated States except US): **PHOTONIUM OY** [FI/FI]; Sorronrinne 9, FIN-08500 Lohja (FI).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **RAJALA, Markku** [FI/FI]; Klaavuntie 9 A 3, FIN-00910 Helsinki (FI).
- (74) Agent: **TAMPEREEN PATENTTITOIMISTO OY**; Hermiankatu 12 B, FIN-33720 Tampere (FI).
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- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: A PREFORM, A HEAD PART FOR A PREFORM AND A METHOD FOR MANUFACTURING A FIBRE



(57) Abstract: A preform, a head part for a preform and a method for manufacturing a fibre are described. Said head part being adapted to be attached to a preform of a fibre. Said head part has such a shape that a heat load directed to said preform will be distributed to the cross section of said bulk part in a predetermined manner, like evenly distributing the heat load to the cross section of the preform. When manufacturing a fibre from a preform comprising such a head part the heating of the preform is more controllable thus resulting in a fibre with a better quality.

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A PREFORM, A HEAD PART FOR A PREFORM AND A METHOD FOR MANUFACTURING A FIBRE

5 The field of this invention is manufacturing a fibre and a preform used in fibre manufacturing process.

10 Fibre optics is used in various optical systems. For example in the recent years more and more electrical communication is moved from traditional copper wires relaying electrical current to optical fibres in which the signal is transmitted using pulses of light.

15 In figure 1 the basic operation principle of a traditional optical fibre is presented. At its simplest form the optical fibre 10 comprises a core layer 11 surrounded by a clad layer 12. A total reflection takes place when a beam of light travelling in the core layer 11 hits the boundary between the two layers, but only if the index of reflection of the clad layer 12 on the used wavelength is sufficiently smaller than the index of reflection of the core layer 11. Because of this total reflection the beam of light stays inside the core layer 11, thus allowing the fibre to be used for transmitting light.

20 Another type of an optical fibre known from the prior art is a fibre that has a non-homogenous region inside i.e. inside a fibre there is a region where some of the characteristics of a fibre are not constant. One example of such non-homogenous regions is the "holey in a fibre"-type construction described below.

30 In the figure 2 a method according to US patent 5,802,236 for manufacturing a "holey in a fibre"-type optical fibre. In the "holey in a fibre"-type fibre the difference of index of reflections which causes the total reflection is caused by small pipes 21 that have been placed around the core layer 22. During the manufacturing process the diameter of these so called capillary pipes is contracted so that the light travelling in the fibre does not "see" the pipes as individual boundaries
35 anymore, but as changes in the index of reflection. This is because part of the light penetrates into the capillary pipes and "sees" the index of

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reflection of the material inside the pipe e.g. air with $n=1.0$. Thus the "holey in a fibre"-type fibre can also be used for transmitting light.

5 By placing these capillary pipes with a predetermined manner around the core layer a change in the index of reflection is achieved even if same bulk material is used in both layers. In the traditional optical fibres the core and clad layers are made of different materials.

10 Manufacturing "holey in the fibre"-type optical fibres is quite a challenging task. For a fibre to work as planned the holes in the pipes must maintain their size and tolerance throughout the length of the whole fibre. Fibres with holes of reasonable size when compared to the diameter of the fibre can be manufactured by drilling holes in a cylindrical preform and pulling this cylinder in order to form a fibre.
15 Another way also known from prior art is to manufacture a preform by packing pipes made of glass or other suitable material to a bundle and pulling the preform in order to form a fibre.

As told above the preform used to manufacture "holey in a fibre"-type
20 optical fibres comprises holes, that can be manufactured by any means known as such to a man skilled in the art, e.g. the two ways described above. These holes contain some medium, typically air. If the preform has a large number of holes, the fibre could have quite different characteristics when compared to a fibre without holes. This difference
25 must be considered in various steps in the fibre manufacturing process.

When a fibre is pulled from a preform, a preform is typically heated in an oven having cylindrical heating elements directing the heat load to the preform placed along the axis of the oven. The main heat transfer
30 mechanism is radiation, i.e. the electromagnetic radiation radiating from the heating element is absorbed in the preform and thus heating the preform. As the bulk material of the preform, e.g. glass, has typically quite different characteristics than the medium, e.g. air, in the holes the heat is not absorbed uniformly and thus non-homogenous heating is
35 produced.

In the figure 3 a prior art system for pulling a fibre is presented. A preform 31 is placed along the symmetry axis of the heating elements 39 forming a cylinder. Pulling is done along the symmetry axis of the cylinder.

5

When a new preform is placed in the oven a pulling mean 34 is connected to the head surface 33 of the preform. When the heat load from the heating elements 39 causes the head surface 33 of the preform 31 to change into a more viscose state, a pull from the pulling mean 34 causes the fibre to emerge from the preform (thus the term "pulling a fibre").

10

Due to the cylindrical shape of the oven the heat load from the heat elements 39 is mostly directed to preform surfaces 35 parallel to the said elements 39. Heat load directed to the head surface 33 of the preform, which is typically aligned perpendicularly to the cylinder axis of the elements, is significantly smaller than the heat load to the preform surfaces 35 parallel the heat elements 39. This uneven heat load causes uneven temperature profile across the cross-section of the head surface, the temperature near the axis being lower than the temperature on the outer regions of the preform.

15

20

The non-uniform heating is a problem of the prior art. Non-uniform heating makes the manufacturing process difficult to control, specially when producing "holey in a fibre"-type fibres, where both disadvantages of the prior art described above are present. Due to these factors the yield in a process making "holey in a fibre"-type fibres is typically significantly smaller than in the process of making traditional optical fibres.

25

30

It is an object of this invention to overcome the disadvantages of the prior art. With an embodiment according to this invention the manufacturing process is easier to control than a prior art process. With improved quality control the overall yield will increase. Thus with this invention high quality fibres are more economical to manufacture than with the prior art solution.

35

In one embodiment of a preform according the invention, a head part is attached to a bulk part of a preform. Said head part has such a shape that a heat load directed to said preform will be distributed over the cross section of said bulk part in a predetermined manner. This would give a possibility to have an improved control over the temperature profile of the preform, which would help to overcome the problems of the prior art. In one embodiment the shape of said head part is such that said heat load is more evenly distributed to said cross section than it would be without said head part.

10

In another embodiment the head part is at least partly cone-shaped. A cone-shaped head part would be a geometrically simple to manufacture, but still providing the effect of distributing the heat load evenly over the cross section of the said preform.

15

In one embodiment the whole cross section of said head part facing said bulk part is substantially equal to the cross section of said bulk part. The cross section of said head part opposite to said cross section facing the bulk part is smaller than said cross section facing the bulk part.

20

In one embodiment said head part can be manufactured of amorphous material. In other embodiment the material of said head part is compatible with the material of said bulk part. Some possible compatible combinations for said head and bulk part materials comprise (material of the head part named first) glass-quartz, glass-phosphate glass and glass-fluoride glass. Some of the materials used can be doped to achieve modifications to their characteristics.

25

In one embodiment some heat absorption material is added to the head part to increase the heat absorption.

30

Said head part and said bulk part can be joined together e.g. by process of melting and solidifying or by using a mechanical joint.

35

In one embodiment said bulk part comprises at least one non-homogenous region to produce a desired variation to the characteristics

of the fibre. Non-homogenous region could comprise e.g. holes, amorphous material with an index of reflection different than the index of reflection of the main material used in said bulk part or amorphous material that is doped with rare earth.

5

In the following a present invention will be described in more detail with the reference to the appended figures, in which

10 Fig.1 illustrates a basic operation principle of a traditional optical fibre,

Fig.2 illustrates schematically a "holey in a fibre"-type optical fibre,

15 Fig. 3 illustrates a prior art system for pulling a fibre, and

Fig. 4 an embodiment of the invention based on a cone-shaped head part,

20 Figures 1, 2 and 3 have been described in relation to prior art.

20

In the following some embodiments of the present invention are presented. These embodiment are exemplary in nature and are not to be interpreted as limiting the scope of protection to only those specific embodiments shown.

25

30 In figure 4 an embodiment of the present invention is presented. A preform having a bulk part 41 similar to one presented in figure 3 is placed inside an oven having heating elements 39 producing the heat load that increase the viscosity of the preform 41. In this embodiment a cone-shaped head part 42 is attached to the bulk part 41.

30

If the preform is moved to a hot region of the oven from the direction of arrow 49 the head part 42 will enter the hot region before the bulk part 41. Thus the head part 42 starts warming up before the bulk part 41.

35

The heat load absorbing to the outer part of the material of the head part 42 heats the material and the convection adds an additional heat

load to the inner part of the head part 42, as shown by arrows 47 in the figure 4. Because of the narrower end 42a of the head part 42, a greater heat load per volume is directed to the narrower end 42a than to the wider end 42b closer to the bulk part. This results in a greater
5 heat load to the axis 48 than if the head part 42 would have a cylinder shape, causing a more uniform temperature profile over the cross section of the head part 42 and eventually also the bulk part 41. In another words the head part 42 distributes the heat load directed to it uniformly to the bulk part 41. Thus the solution removes the
10 disadvantages of the prior art.

The idea presented is not limited to producing even temperature profiles, but a head part with a different shape could also be made to produce some other predetermined temperature profile.
15

The head part 42 presented in figure 4 is a truncated cone. However, the head part 42 distributing the heat to the bulk part 41 could also be manufactured to other shapes than cones or truncated cones.

20 In the embodiment presented in fig. 4 the cross-section 42b of the head part 42 facing the bulk part 41 is substantially equal to the cross-section of bulk part 41. The cross-section 42a, opposite to the said cross-section 42b, is smaller than said cross-section 42b facing the bulk part 41. For some other embodiments the cross-section of the head part 42
25 could as be greater or smaller than the cross-section of the preform.

As the head part 42 and the bulk part 41 are connected to each other to form a preform used for pulling a fibre it is advantageous that the bulk part 41 and the head part 42 are made of compatible materials. Head
30 part 42 could comprise glass or another amorphous material and the bulk part could comprise e.g. quartz, phosphate glass, or fluoride glass. Each material mentioned could be either pure or doped with suitable dopant material, the head part 42 could comprise for example some heat absorbing material for increasing the amount of heat absorbing in
35 the head part 42.

The head part 42 and the bulk part 41 could be connected to each other e.g. by welding, i.e. process comprising steps of melting and solidifying. It is specially noted that it is not necessary that the parts are connected on the whole diameter of the joint.

5

Another possibility to combine head part 42 with the bulk part 41 is that a mechanical join is manufactured, so that surfaces are locked to each other when combined.

- 10 If a variation of some of the characteristic inside a fibre is needed, this could be carried out by producing at least one non-homogenous region into the fibre. This non-homogenous region could comprise e.g. holes, an amorphous material with an index of reflection difference than the index of reflection of the main material used in said bulk part or
- 15 amorphous material that is doped with rare earth. The invention presented is well suited for manufacturing this kind of fibres as the manufacturing processes in this case are typically more difficult to control than the conventional fibre manufacturing processes due to the non-homogenous structure of the fibres

20

- It is to be understood that although the present invention has been specially disclosed with preferred embodiments and examples, modifications to these may be apparent to a man skilled in the art and such modifications and variations are considered to be within the scope
- 25 of the invention and the appended claims. It is also intended that all the matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

Claims:

1. Preform of a fibre comprising a head part (42) and a bulk part (41),
characterised by that

5

said head part (42) having such a shape that a heat load directed to said preform will be distributed to the cross section of said bulk (41) part in a predetermined manner.

10 2. Preform according to claim 1 **characterised by that** shape of said head part (42) is such that said heat load is more evenly distributed to the said cross section that it would be without said head part (42).

15 3. Preform according to claim 1 **characterised by that** said head part (42) is at least partly cone shaped.

4. Preform according to claim 1 **characterised by that** said head part (42) comprises amorphous material.

20 5. Preform according to claim 1 **characterised by that** said head part (42) and said bulk part (41) are made of compatible materials

25 6. Preform according to claim 5 **characterised by that** said bulk part (41) comprises pure or doped quartz and said head part (42) comprises glass.

30 7. Preform according to claim 5 **characterised by that** said bulk part (41) comprises pure or doped phosphate glass and said head part (42) comprises glass.

8. Preform according to claim 5 **characterised by that** said bulk part (41) comprises pure or doped fluoride glass and said head part (42) comprises glass.

35 9. Preform according to claim 1 **characterised by that** said head part (42) comprises material increasing the heat absorption.

10. Preform according to claim 1 **characterised by that** said head part (42) and said bulk part (41) are at least partly joined together by process of melting and solidifying.
- 5 11. Preform according to claim 1 **characterised by that** said head part (42) and said bulk part (41) are at least partly joined together by a mechanical joint.
- 10 12. Preform according to claim 1 **characterised by that** cross-section of said head part (42) on the side facing said bulk part (41) is substantially equal to the cross-section of said bulk part (41) and the cross-section of said head part (42) opposite to said bulk (41) part is smaller than said cross-section facing said bulk part (41).
- 15 13. Preform according to claim 1 characterised by that said bulk part (41) comprises at least one non-homogeneous region.
- 20 14. Preform according to claim 13 **characterised by that** said at least one non-homogeneous region comprises a hole.
- 25 15. Preform according to claim 13 **characterised by that** said at least one non-homogeneous region comprises an amorphous material with an index of reflection difference than the index of reflection of the main material used in said bulk part.
- 30 16. Preform according to claim 13 **characterised by that** said at least one non-homogeneous region comprises an amorphous material that is doped with rare earth.
- 35 17. A head part for a preform of a fibre **characterised by that** said head part (42) having such a shape that a heat load directed to said preform will be distributed to the cross section of said bulk part in a predetermined manner.
18. A head part according to claim 17 **characterised by that** shape of said head (42) part is such that when placed on said preform said heat load is more evenly distributed to the said cross section that it would be

without said head part (42).

19. A head part according to claim 17 **characterised by that** said head part (42) is at least partly cone shaped.

5

20. Method for manufacturing a fibre comprising steps of

heating a preform so that a surface of the preform is at least partly transformed to a form suitable for pulling a fibre and

10

directing a pulling effect to at least the transformed part of the preform,

characterised by that the method further comprising step of

15

controlling at least partly the heating of at least a part of said surface by a head part (42) attached to a said surface.

21. Method according to claim 20 **characterised by that** said step of controlling is such that the heat load is more evenly distributed to the cross section of said surface that it would be without said head part (42).

20

22. Method according to claim 20 **characterised by that** said head part (42) is at least partly cone shaped.

25

23. Method according to claim 20 **characterised by that** the method further comprise steps of joining at least partly said head part (42) to a bulk part (41) of said preform.

30

24. Method according to claim 23 **characterised by that** said step of joining precede said step of heating.

25. Method according to claim 23 **characterised by that** said step of joining further comprises steps of melting and solidifying.

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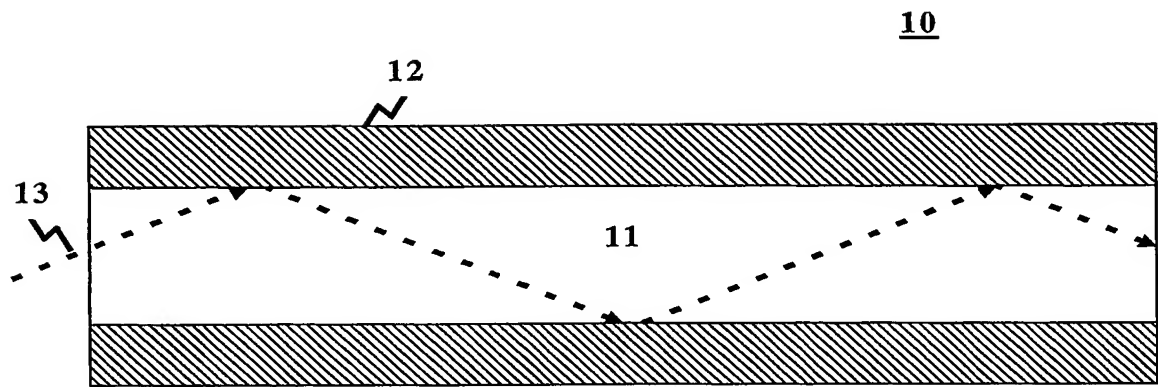


Fig. 1

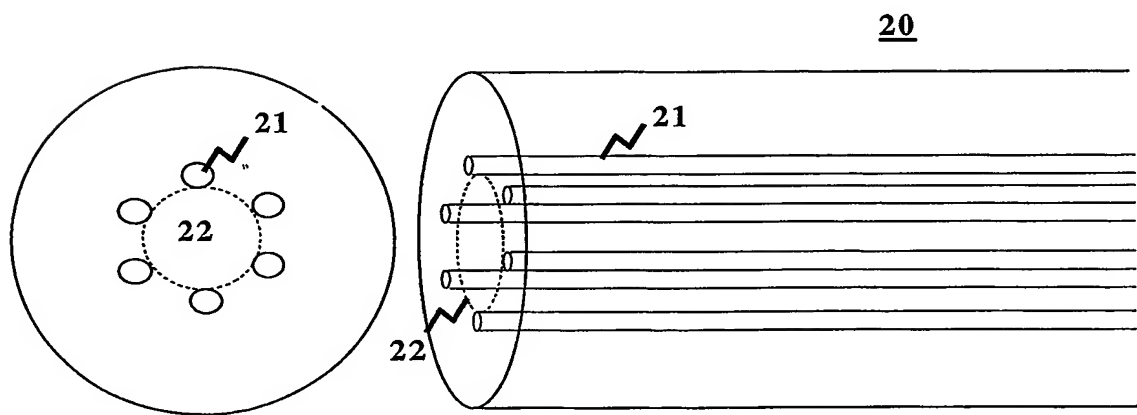


Fig. 2

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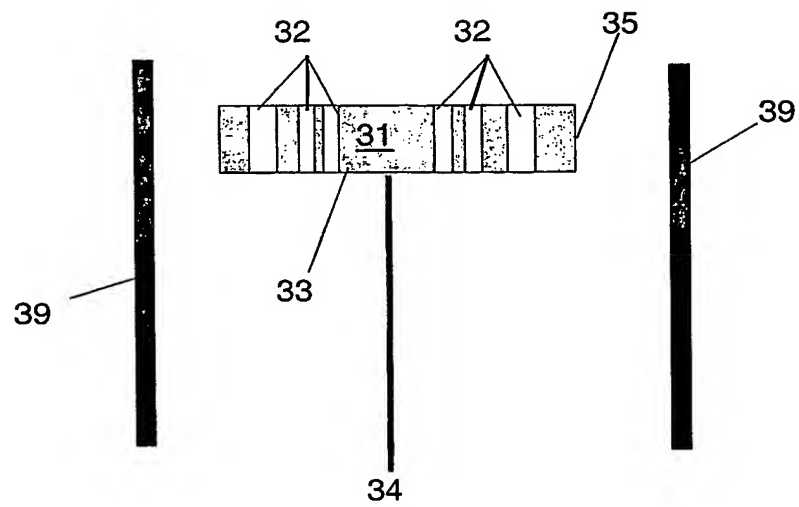


Fig. 3

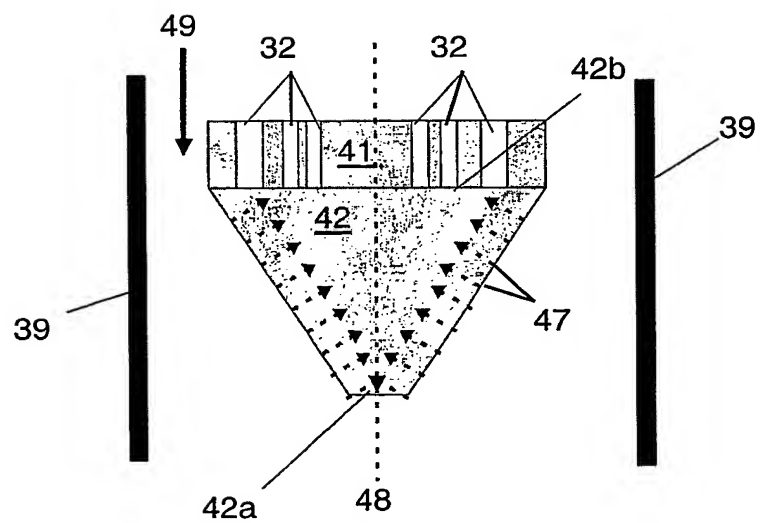


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 03/00473

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C03B 37/025, C03B 37/012, C03B 37/07
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI DATA, EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5167684 A (MARC TURPIN ET AL), 1 December 1992 (01.12.92), column 3, line 48 - line 54, figure 3 -- -----	3,12,19, 20-25

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

2 Sept. 2003

Date of mailing of the international search report

02 -09- 2003

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

Linda Melin/MP
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI03/00473

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1, 2, 4-11, 13-18
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

See extra sheet

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

Present claims 1, 2, 4-11 and 13-18 relate to a preform comprising a head part and a head part for a preform defined by reference to a desirable characteristic or property, namely the head part having such a shape that a heat load directed to said preform will be distributed to the cross section of the bulk part (of the preform) in a predetermined manner. The claims cover all preforms and head parts having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and / or disclosure within the meaning of Article 5 PCT for only a very limited number of such preforms and head parts. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible.

Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). An attempt is made to define the preform and the head part by reference to a result to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible.

Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the preform and the head part where the shape of the head part is geometrically defined, i.e. claims 3, 12 and 19.

INTERNATIONAL SEARCH REPORT
Information on patent family members

26/07/03

International application No.

PCT/FI 03/00473

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5167684 A	01/12/92	AU 629709 B	08/10/92
		AU 6764490 A	06/06/91
		DE 69015986 D,T	18/05/95
		EP 0430781 A,B	05/06/91
		FR 2655326 A,B	07/06/91
